Reconstructing diet, tracing mobility

Panagiotopoulou, Eleni

Chapter 2 • Diet and social stucture in Halos

Isotopic (^{13}C, ^{15}N) investigation of diet and social structure in Early Iron Age Halos, Greece[1]

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Abstract

This paper integrates the isotopic results on dietary variation with an in-depth contextual analysis of mortuary data from two Early Iron Age cemeteries in Halos, Thessaly, central Greece. While the diet was mainly based on C_3 plant and animal protein, there is evidence for the consumption of C_4 resources (millet) by a few females, but also increased meat consumption by some individuals, sometimes furnished with weapons or other wealthy offerings. In addition, infants, children and adults in the two cemeteries show a difference in $\delta^{15}N$ values. The analysis therefore reveals possible emerging differentiation between age, sex and possibly status groups in a crucial period of Greek prehistory, after the disintegration of the Mycenaean palatial societies and the ensuing period of regression.

Keywords: Stable isotopes, Diet, Mortuary analysis, Early Iron Age, Greece

2.1. Introduction

The Early Iron Age in mainland Greece (EIA, 1100-700 BCE) is a transitional period, which starts after the gradual disintegration of the Mycenaean palatial societies and ends with the formation of the Archaic city-state. While the period is characterized by decline and social regression in the earlier part of the period (Submycenaean and Protogeometric periods, 1100-900 BCE), there are nevertheless some signs of nascent divisions between social groups (Dickinson 2006; Georganas 2009; Georganas 2002; Lemos 2013). These are primarily visible in the mortuary record, which is characterized by diversity

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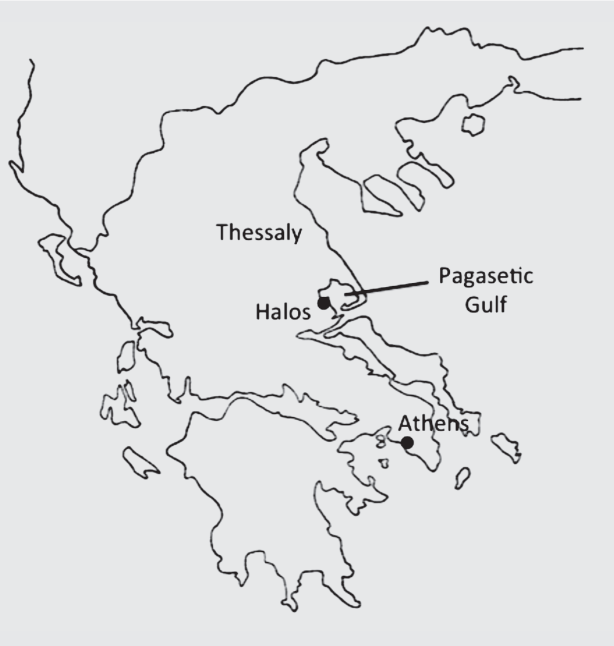

Figure 2.1: Map of Greece showing the location of the Halos site.

and the co-existence of traditional forms and new practices.

In this paper, we explore the correlation between the diet and the social structure of an EIA community. We employ two methods: a) stable carbon and nitrogen isotope analysis of bone collagen for paleodietary investigation, and b) the contextual analysis of the mortuary practices for the reconstruction of social differentiation.

We argue that an in-depth contextual analysis of the mortuary data allows us to reconstruct the social structure of the Early Iron Age communities (Mee and Cavanagh 1984; Voutsaki 1998), but also provide the starting point for an informed sampling strategy and the framework for a nuanced interpretation of the isotopic results. Isotopic data need to be controlled against the contextual observations on the mortuary data. In this way, isotopic data and observations on dietary variation are controlled against the patterning in the mortuary record.

The site of Halos (Figure 2.1) is excellently suited for an integrated analysis of isotopic and mortuary data. The site is located in eastern Thessaly, in the northern margins of the Mycenaean world (Eder 2009; Feuer 2011; Papadimitriou 2008) and was affected by the demise of the Mycenaean centres. Halos is situated on the land routes that connected the southern and northern mainland and very near important maritime routes along the Pagasetic Gulf (Stissi et al. 2004) (Figure 2.1).

The Early Iron Age has been well studied (Dickinson 2006; Georganas 2002; Georganas 2009; Lemos 2002; Lemos 2013; Mazarakis-Ainian 1997; Mazarakis-Ainian 2012; Snodgrass 2006) but only few detailed contextual analyses of mortuary data (Tsiouka 2008; Viziinou 2010) have been undertaken. Even fewer isotope analyses have been undertaken on material from this period (Panagiotopoulou and Papathanasiou 2015; Papathanasiou et al. 2013; Triantaphyllou 2015). An indirect aim of our study therefore, is to emphasize the potential of isotopic studies for a better understanding of social change in this key period of Greek prehistory.

This paper focuses on the mortuary practices and osteological assemblages of two cemeteries of Halos dating to the Protogeometric period.

These cemeteries, Voulokaliva and Kephalosi, were discovered during res- cue excavations for the construction of the Athens-Thessaloniki highway (Malakasioti 2001; Nikolaou 1998). The cemetery of Kephalosi is situated within the borders of the Hellenistic town of Halos (300-265 BCE). The cemetery of Voulokaliva, is situated ca. 2 km to the north of Kephalosi. Both possibly belonged to the same settlement (Figure 2.2).

As pointed out above, the Protogeometric period shows marked variety in burial practices; cemetery settings, tomb types, modes of treatment and offerings vary considerably (Dickinson 2006; Georganas 2009; Lemos 2013; Tziafalias and Zaouri 1999; Viziinou 2010). The question therefore is: What causes this variation? Can we reconstruct age, sex and status divisions on the basis of the mortuary data? And are any patterns in the mortuary record confimed by the isotope analyses?

Cemeteries in this period are either intra-mural or extramural. It has already been observed that mostly subadults are buried among the houses (Mazarakis-Ainian 2010). In contrast, extra-mural, formal cemeteries nearby the settlement, for example in Lefkandi (Lemos 2002), were used for both adults and subadults, and for both men and women. The dominant tomb types are pits, cists and small tholoi (Dickinson 2006; Georganas 2009), the latter being a traditional, 'Mycenaean' form. The bodies are either inhumed as in the Mycenaean pe- riod (Lewartowski 2000), or cremated (Dickinson 2006; Lemos 2002). While previously multiple burials constituted the norm, in this period multiple and single burials co-exist in the same cemetery (Georganas 2009). Protogeometric tombs contain, in general, fewer offerings than in the Mycenaean period, though pottery (usually cups, jugs or feeding bottles) as well as a few metal (both iron and bronze) weapons, tools and ornaments are found. The distribution of richer offerings does not always show a clear pattern, though rich offerings tend to accompany subadults or men, in which case they sometimes include weapons (Georganas 2005; Lemos 2006).

2.2. Material and methods

2.2.1 Material

i. The Protogeometric cemetery of Kephalosi

There is good evidence that Kephalosi was an intramural cemetery, as the graves are associated with a contemporary domestic building, which contained storage jars (Malakasioti, 2009; Nikolaou and Papathanasiou, 2012). The fact that the graves contain almost exclusively subadult burials strengthens this conclusion. The prevailing burial practice is single primary inhumation in cists; the dead are buried in extended (n=5), semi-contracted (n=4) or contracted (n=2) position. Seventeen out of 22 graves contained offerings such as ceramic vases, copper and iron ornaments as well as one iron knife, a bone pendant, a stone bead and shells (Megalokonomou and Spanodimos 2007; Nikolaou 1998).

ii. The Protogeometric cemetery of Voulokaliva

The site of Voulokaliva (Figure 2.2) is a large cemetery, which was used continuously from the later Mycenaean period (Late Helladic IIIB and LH IIIC phases, ca. 1300-1100 BCE) through to the Submycenaean (ca. 1100-1050 BCE) and Protogeometric (ca. 1050-900 BCE) periods, and re-used during Hellenistic times (ca. 300-265 BCE) (Malakasioti 2009; Reinders 2003). This paper focuses on the thirty-eight Submycenaean and Protogeometric graves (Malakasioti and Tsiouka 2011; Tsiouka 2008).

A number of graves form clusters (2 to7 graves), whereas others are scattered across the burial

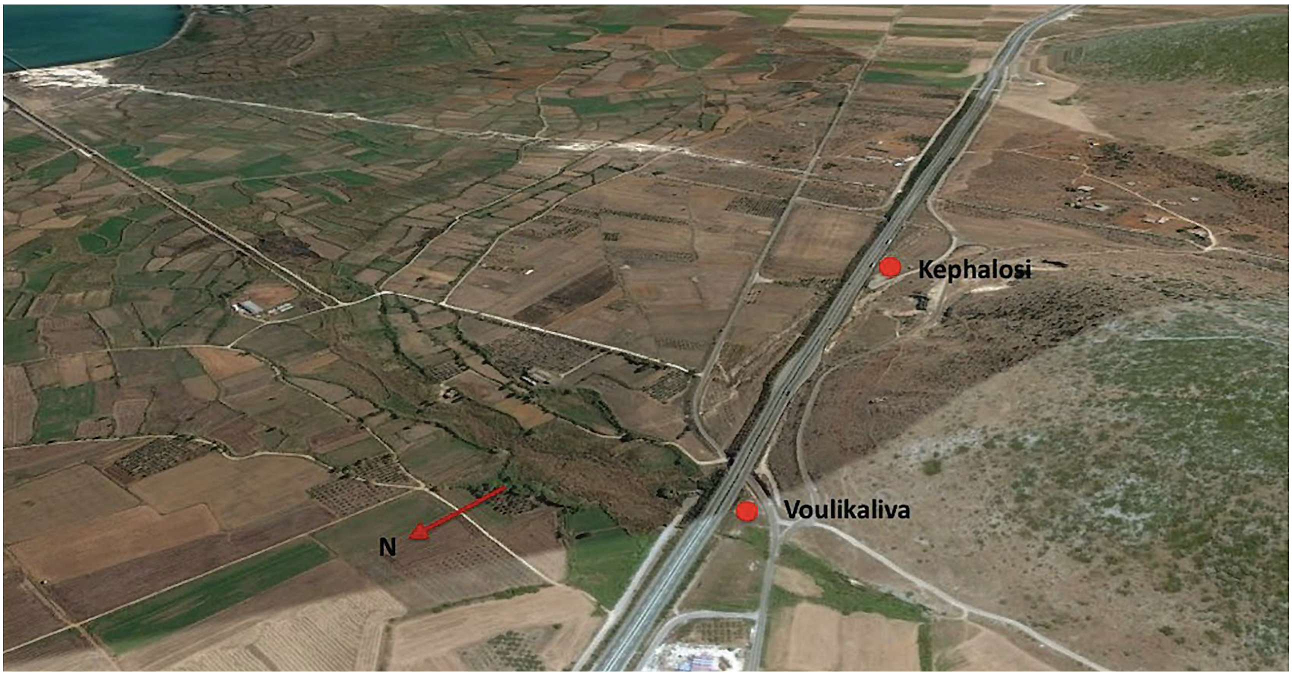

Figure 2.2: Photograph of the investigated cemeteries of Halos: Kephalosi and Voulikaliva.

ground (Tsiouka 2008). Due to the fact that this was a rescue excavation and only part of the cemetery has been exposed, we cannot fully reconstruct the spatial organisation of the cemetery. Tomb types in Voulokaliva are more diverse than in Kephalosi; they include pits, cists, burial jars and one circular construction with single and double inhumations. The circular construction may represent a rudimentary imitation of *tholoi*, that is subterranean vaulted tombs used for multiple burials during the Mycenaean period (Georganas 2000). It contains only two primary burials, just as a few cists with double burials found in the same cemetery. Most bodies were placed in contracted (n=12) or semi-contracted position (n=13), but few extended burials (n=6) were found as well.

The offerings in the tombs consist mainly of pottery, iron tools and weapons, bronze and iron ornaments, but also a gold hair spiral, as well as bone and stone buttons, rings and beads.

2.2.2. Methods

i. Age-sex determination

The osteological analysis of the material was based on the standard procedures of Buikstra and Ubelaker (1994) for complete and commingled material. The basic demographic parameters of the population (Minimum Number of Individuals or MNI, age and sex) were estimated in order to provide the basis for the contextual and isotope analysis. Sex and age estimation was carried out following the methods presented in Buikstra and Ubelaker (Buikstra and Ubelaker 1994) including patterns of robusticity and cranial and pelvic morphology. Only adults with mature characteristics have been sexed.

ii. Contextual analysis

Stable carbon and nitrogen isotope analysis of bone collagen is an established method used to reconstruct the diet of past societies (Fry 2006; Fuller et al. 2006; Hedges and Reynard 2007; Kuitems et al. 2015; Richards et al. 2005). Human diet is of course closely related to access to resources and therefore to an individual's social and economic position and to the social structure of the community as a whole. Since this paper examines the relation between diet and social structure, the contextual analysis of the archaeological data is a fundamental component of the study. For this purpose, variation in all aspects of evidence such as cemetery organisation, tomb types, treatment of the body, and offerings was studied, and all these aspects were then correlated with the sex and age of the deceased. The observed patterns reveal the degree of differentiation within a community, as well as the main principles and divisions structuring social life.

iii. Sampling strategy for diet reconstruction

Our main goal was to examine whether the diet of the buried individuals varied significantly, and whether it correlated with variation in the mortuary treatment. Our sampling strategy was based on the results of the contextual analysis therefore had to include samples from both cemeteries and all clusters, from different tomb and burial types, from all mortuary wealth groups, but also different age and sex groups.

Poor preservation of the skeletal material also had to be taken into account. While all graves were included in the contextual analysis of the cemetery, isotope analysis was carried out only on well-preserved skeletons. In addition, animal bones from contemporary layers were also sampled in order to establish the local food web. Twenty-two human and two animal samples (goat/sheep, cattle) from Kephalosi and 31 human and seven animal samples (cattle, goat/sheep and equine) from Voulokaliva have been processed. No pathological bone was sampled. The samples from humans were taken from femora or ribs.

iv. Isotope analysis

The carbon and nitrogen stable isotope analysis of bone collagen from the two cemeteries of Halos was carried out at the Center for Isotope Research at the University of Groningen. The collagen was extracted following an improved version of the Longin method (Longin 1971). First the samples were cut to the appropriate size and weight. Loose soil and dirt were removed mechanically and the samples were placed in acid (1% HCl) to demineralize the bone. A weaker than usual acid solution was used because of the preservation state of the samples. A 1% NaOH bath removed humic acids. Next, the samples were first placed in slightly acidic demineralized water and then in an oven in order to solubilize the organic part, that is the collagen fraction of the bone. The solution was filtered (50 µm) in order to collect the pure collagen solution. Finally, the solution was dried into solid collagen.

The collagen was combusted and purified into gas (CO_2 and N_2 for 13C and ^{15}N analysis, respectively) using an Elemental Analyser (EA), coupled to an Isotope Ratio Mass Spectometer (IRMS). We used two instruments, a Carlo Erba/Optima and an Isocube/Isoprime EA/IRMS combination.

The instruments provide the isotope ratios $^{13}R={}^{13}C/{}^{12}C$ and $^{15}R={}^{15}N/{}^{14}N$ as well as the C and N yields of the collagen. The isotope ratios are expressed in permil deviations from a reference material, reported as delta values:

$$\delta=[R_{sample}/R_{reference}] - 1(x1000‰)$$

The reference materials are the internationally recommended compounds VPDB (belemnite carbonate) for $\delta^{13}C$ and ambient air for $\delta^{15}N$ (DeNiro, 1987; Mook, 2006). The analytical precision is 0.1‰ and 0.2‰ for $\delta^{13}C$ and $\delta^{15}N$, respectively.

For bone collagen, quality parameters are widely accepted values for the carbon content, nitrogen content and the atomic C/N ratio. These values should be in the range 30-45%, 11-16% and 2.9-3.6, respectively (Ambrose 1990; DeNiro 1985; van Klinken 1999). When these values differ significantly, the bone is considered (partly) degraded, and this may produce deviating isotope ratios, and lead to possibly erroneous conclusions.

Table 2.1: Demographic profile and isotopic data for the population of Kephalosi.
The abbreviations indicate, I: Indeterminate, YA: Young adult.

Sample number	Lab no	Sex	Age	Coll. (%)	$\delta^{13}C$ (‰)	C%	$\delta^{15}N$ (‰)	N%	C/N
Halos-Kephalosi									
HK/B7-c3	57219	–	<0	1.1	–19.1	42.4	9.7	15.5	3.2
HK/B7-c6	57220	–	≤ 2 y	1.0	–18.0	45.1	9.9	16.7	3.2
HK/B7-c7	57221	–	1–1.5 y	0.0	–	–	–	–	–
HK/B7-c8	57222	–	9 m	1.2	–18.7	45.7	9.5	16.8	3.2
HK/B7-c9	57223	–	6–9 m	3.7	–18.1	42.9	11.7	15.7	3.2
HK/B7-c10	57224	–	3 y	2.1	–19.1	43.1	10.0	15.8	3.2
HK/B7-c11	57225	–	<0	7.2	–18.6	42.1	10.0	15.3	3.2
HK/B7-c12	57227	–	0	1.1	–19.4	41.6	9.9	15.2	3.2
HK/B7-c14	57228	–	0	5.5	–18.9	44.1	8.8	16.2	3.2
HK/B7-c15	57229	–	7–8 y	7.8	–19.3	43.7	10.2	16.0	3.2
HK/B7-c16	57231	I	YA	3.6	–19.1	44.4	9.7	16.4	3.2
HK/B7-c18	57232	–	8–9 y	2.8	–19.3	42.5	8.7	15.5	3.2
HK/B7-c19	57233	–	<0	3.9	–19.3	42.5	9.2	15.6	3.2
HK/B7-c20	57234	–	4 y	0.7	–18.3	43.4	10.3	16.0	3.2
HK/B7-c22	57235	–	4 y	1.2	–19.6	44.0	8.9	16.2	3.2
HK/B7-c23	57236	–	≤ 2 y	0.6	–17.2	46.5	11.3	17.3	3.1
HK/B7-c24	57237	–	5–6 y	1.9	–19.4	43.0	8.9	15.7	3.2
HK/B6-c43	57238	–	6 y	0.02	–19.4	28.4	9.5	11.4	2.9
HK/B6-c46	57239	–	3–6 m	4.0	–19.0	42.8	9.7	15.7	3.2
HK/B6-c49	57240	–	0	0.3	–19.1	41.4	10.7	15.1	3.2
HK/B6-c54	57241	–	1 y	0.8	–19.2	43.1	9.2	16.1	3.1
HK/*B*1-c-52	57242	–	7 y	0.1	–19.5	44.9	7.8	16.8	3.1

2.3. Results

2.3.1. Collagen preservation

The samples from Kephalosi fall within the acceptable range of the C/N ratio (3.1 to 3.2) as well as the C and N contents, except two (sample HK/B7-c7 yielded no collagen while sample HK/B6-c43 did not exhibit acceptable parameters %Coll: 0.02%, %C: 28.4%). Thus, almost all samples (91%) are well preserved and suitable for this study (Table 2.1). Twenty-six of the 32 human samples from Voulokaliva yielded collagen. Four samples were excluded either because of non-acceptable diagenetic parameters (C/N: HaVo/e-c37/ind1=2.88 and HaVo/w-c12/ind1=2.6, %Coll: HaVo/e-cc8/ind2, HaVo/e-p65, HaVo/e-c81 and %C-%N: HaVo/w-c7/ind2=85.8%/31.4%). The accepted samples from Voulokaliva represent 81.5% of the total number. This high percentage shows that the collagen is well preserved (Table 2.2). Almost all animal samples yielded collagen; one sample from Voulokaliva had very low C (7.7%) and N (2.88%) content, and one from Kephalosi did not yield collagen. Both are excluded from our study.

2.3.2. Demographic profile and contextual analysis

The demography of the Kephalosi cemetery is composed of 22 subadults, all younger than 10 years-old, and only one indeterminate adult. Eight individuals ranged between the ages of three to ten years. The remaining 14 individuals ranged from neonates to 3 years old (Table 2.2); three individuals from this group are foetuses. There was also one case of twin neonates with concurrent death (Nikolaou and Papathanasiou 2012).

Voulokaliva, a formal extramural cemetery, has more varied demo- graphic composition. Twenty adults –males or probable males (n=8), females or probable females (n=6), and individuals of indeterminate sex (n=6) – and 21 subadults – infants (n=5), children 3 y–10 y (n=5), adolescents (n=4) and subadults whose age could not be determined further (n=7), were identified in Voulokaliva.

Therefore, adults and subadults (0–18 y) were almost equally represented in Voulokaliva. However, since infant mortality in pre-industrial societies was very high –it is expected to be up to 50% (Bocquet-Appel and Masset 1977; Masset 1973)– infants are actually underrepresented here. In formal extra mural cemeteries the exclusion of infants and their burial in intra mural cemeteries was practiced. However, we cannot, yet, be conclusive on the above observation because the cemetery of Voulokaliva is not fully excavated and we still do not know the complete assemblage buried in this ground. In Kephalosi, on the other hand, infants predominate, which suggests that this site may contain the individuals missing from Voulokaliva (Figure 2.3).

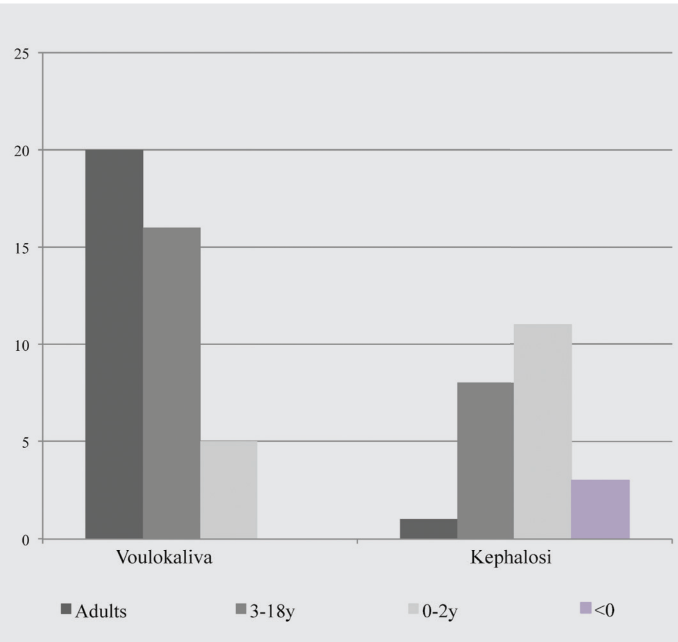

Figure 2.3: Demographic profile of the cemeteries of Halos (Single column).

We see therefore that age divisions underlie the differentiation between intramural and extramural burial. Age affects also other aspects of the evidence. Children in Voulokaliva were often buried in jars, or in cists together with an adult or another subadult. However, the differentiation is not rigid: both cemeteries contain all age groups –young children are found in Voulokaliva and one adult was buried in Kephalosi; cists predominate in both cemeteries and inhumation is the rule for everyone.

Table 2.2: Demographic profile and isotopic data for the population of Voulokaliva. The abbreviations indicate, M(?): Male or probable male, F(?): Female or probable female, I: Individual of indeterminate sex, OA: Old adult, YA: Young adult, Ad: Adult.

Sample name	Lab no	Sex	Age	Coll. (%)	δ13C (‰)	C%	δ15N (‰)	N%	C/N
Halos-Voulokaliva									
HaVo/e-c5	57304	I	20–25 y	1.6	–19.2	42.3	9.4	15.4	3.2
HaVo/e-cc8/ind1	57305	I	Ad	1.9	–19.4	39.0	8.7	14.1	3.2
HaVo/e-cc8/ind2	57306	I	Ad	0.0	–	–	–	–	–
HaVo/e-c12/ind1	57307	M	Ad	2.5	–20.0	42.1	8.5	15.6	3.1
HaVo/e-c12/ind2	57308	F	Ad	1.0	–19.4	42.5	8.6	15.8	3.1
HaVo/e-c29	57309	–	9 m	0.6	–19.4	45.0	8.5	16.4	3.2
HaVo/e-c36	57310	–	4 y	0.4	–18.5	41.4	9.0	15.6	3.1
HaVo/e-c37/ind1	57311	–	1 y	0.2	–19.3	38.2	8.6	15.6	2.9
HaVo/e-c37/ind2	57312	–	3 y ± 12 m	1.5	–19.9	42.5	8.1	15.9	3.1
HaVo/e-p40	57313	–	18 m	0.3	–18.2	44.9	10.7	16.8	3.1
HaVo/e-c46	57314	M?	18–20 y	1.9	–19.4	41.9	6.8	15.4	3.2
HaVo/e-c59	57315	–	11 y	3.0	–20.0	44.2	8.3	16.2	3.2
HaVo/e-p65	57316	M?	35–45 y	0.0	–	–	–	–	–
HaVo/e-p66	57317	F?	25–40	2.1	–19.6	42.2	8.1	15.7	3.1
HaVo/e-c70	57318	–	3 y	3.1	–19.2	42.5	7.1	15.6	3.2
HaVo/e-c72	57319	M?	25–45 y	2.3	–18.5	42.2	8.7	15.6	3.2
HaVo/e-c81	57320	–	18 m	0.0	–	–	–	–	–
HaVo/w-c7/ind1	57321	M	30–50 y	2.0	–19.5	31.0	8.7	11.3	3.2
HaVo/w-c7/ind2	57322	F	35–40 y	2.1	–17.8	85.8	7.7	31.4	3.2
HaVo/w-c11/ind1	57323	I	OA?	2.2	–19.6	41.5	7.5	15.3	3.2
HaVo/w-c11/ind2	57621	I	20–35 y	2.9	–19.4	39.9	8.3	14.9	3.1
HaVo/w-c12/ind1	57622	–	11 y	0.03	–19.6	37.3	6.8	16.5	2.6
HaVo/w-c12/ind2	57623	M	M>30y	0.1	–19.7	31.0	8.1	11.6	3.1
HaVo/w-c13	57624	–	16–18 y	0.5	–19.6	41.2	6.9	15.5	3.1
HaVo/w-c17	57625	–	4 y	1.2	–18.3	40.9	9.4	15.1	3.2
HaVo/w-c21	57626	F	30–40 y	2.8	–17.5	41.5	8.6	15.3	3.2
HaVo/w-p31	57627	I	YA	1.9	–19.7	31.3	8.7	11.4	3.2
HaVo/w-p38/ind1	57628	M	YA	1.9	–18.5	41.4	9.1	15.2	3.2
HaVo/w-p38/ind2-sec	57629	F	35–39 y	1.7	–17.0	36.8	8.5	13.4	3.2
HaVo/w-c46	57630	–	16–18 y	2.6	–18.0	43.2	9.1	15.9	3.2
HaVo/w-c52/ind1	57631	M	35–45	2.7	–19.8	42.8	8.0	15.8	3.2
HaVo/w-c52/ind2	57632	F	30–40 y	0.3	–18.8	39.3	7.3	15.1	3.0

Most tombs are non-monumental simple cists and pits, as could be expected in a period of social regression. The circular construction –including two primary inhumations– could be regarded as a more elaborate structure, but also as a poor, small and rudimentary imitation of the traditional Mycenaean *tholoi*. The modest offerings recovered from the interior point more to the second explanation. Different preferences, or an adherence to traditional forms may have played a role.

In contrast, variation in offerings can be observed. However, some caution is needed, as rich offerings do not necessarily imply wealth or high status held in life. It is therefore important to examine if mortuary wealth correlates with other aspects of mortuary behaviour, or facets of personal identities such asage or gender. Richer graves in Halos do not cluster in one place; furnished and unfurnished graves are found in both cemeteries. While the burials in the circular construction were very modest, cists contained a more diverse range of offerings. Some differentiation between age groups can be observed;

Table 2.3: $\delta^{13}C$ and $\delta^{15}N$ values of herbivores from the Halos cemeteries

Sample Number	Lab no	Species	Coll. (%)	$\delta^{13}C$ (‰)	C%	$\delta^{15}N$ (‰)	N%	C/N
HaVo/w-apoth9	57633	Herbivore	3.2	–18.6	42.6	4.1	15.6	3.2
HaVo/w-apoth12	57634	Sheep/goat	3.0	–19.6	42.7	3.7	15.5	3.2
HaVo/w-apoth13	57635	Herbivore	1.5	–19.5	42.7	8.0	15.7	3.2
HaVo/e-apoth9	57636	Sheep/goat	4.0	–19.9	42.8	3.5	15.6	3.2
HaVo/e-apoth11	57637	Cattle	0.7	–17.5	7.7	6.0	2.9	3.1
HaVo/e-apoth15	57638	Sheep/goat	7.3	–20.1	42.6	2.6	15.5	3.2
HaVo/e-apoth16	57644	Equine	1.9	–19.5	39.2	4.4	14.4	3.2
HK/B7-c11 animal	57226	Sheep/goat	0	–	–	–	–	–
HK/B7-c15 animal	57230	Cattle	3.8	–18.8	40.9	8.3	14.9	3.2
Mean value				–19.4		4.9		
SD				0.5		2.3		
MIN				–20.1		2.6		
MAX				–18.6		8.3		

weapons are only found with adults, and feeding bottles are only found in graves of infants. In general, subadults receive a more diverse range of offerings. However, once more overlaps exist, and the differentiation from adults is not absolute.

Differentiation between the two sexes is also attested: weapons are found with males, while females are not accompanied by ceramic offerings. On the other hand, the same types of ornaments were used for both males and females. Either way, we need to be cautious: the large number of indeterminate individuals and the double burials prevent us from reaching firm conclusions on gender differentiation.

To conclude, the systematic examination of all aspects of burial practices in the cemeteries of Halos revealed subtle variations rather than rigid divisions. Age differentiation was certainly a factor, expressed by the placing of infants among the houses and the richer and more diverse assortment accompanying subadults. The deposition of weapons and pottery point to a certain gender differentiation, but the state of the evidence does not allow us to reach firm conclusions on this point. Finally, the burial record in Protogeometric Halos does not show pronounced wealth or status differences. Some variation in the quantity or diversity of offerings exists, but these do not correlate with grave type nor with grave elaboration.

The contextual analysis allows us not only to design our sampling strategy, but also to formulate clearer questions. Do we observe significant variation in the diet of different age groups and sex categories? Do the people buried in richer graves show a different diet? Does dietary variation show the same picture as the mortuary record, that is a society based on age divisions and perhaps some gender differentiation, and only limited (or perhaps just emerging) status differences?

2.3.3. Carbon and nitrogen isotope analysis

The results of the isotope ratio measurements are shown in Tables 2.1 & 2.4 (Kephalosi) and Tables 2.2 & 2.5 (Voulokaliva). The human values from subadults (0–3 years old) of Kephalosi range for $\delta^{13}C$: –19.4‰ to –17.2‰ with a mean value (±1σ) of –18.7‰±0.7‰ and for $\delta^{15}N$: 8.8‰ to 11.7‰ with a mean value of 10.1‰±1.0‰. The isotope ratio of values for adults in Voulokaliva range for $\delta^{13}C$: –20.0‰ to –17.0‰ with a mean value of –19.1‰±0.9‰. For $\delta^{15}N$ these values are: 6.8‰ to 9.4‰ with a mean value of 8.3‰±0,6‰. The human values from subadults (0–3 years old) of Voulokaliva range for $\delta^{13}C$: –19.9‰ to –19.2‰ with a mean value of –19.5‰±0.4‰ and for $\delta^{15}N$: 7.1‰ to 8.5‰ with a mean value of 7.9‰±0.7‰.

The animal values from both sites (Table 2.3) range $\delta^{13}C$: –20.1‰ to –18.6‰ with a mean value of –19.4‰±0.5‰ and $\delta^{15}N$: 2.6‰ to 8.3‰ with mean value 4.9‰±2.3‰ (Table 2.3).

The $\delta^{13}C$ values of the animals and most humans indicated a diet based on C_3 plant resources like vegetables, fruits, and cereals such as wheat and barley (Figure 2.4). Furthermore, the human $\delta^{15}N$ values as they are enriched compared to the local fauna, indicate terrestrial animal protein intake, while aquatic effect did not occur. A few humans showed enriched $\delta^{13}C$ values, which suggests that C_4 plants were possibly present in their diet.

The human $\delta^{15}N$ values suggest that animal protein (dairy products or meat) constituted a significant share of the human diet. The humans are ca. 3‰ higher than the herbivores, which corresponds to a clear trophic level (Kohn et al. 1999). There are two animals, one cattle and an unspecified herbivore, with $\delta^{15}N$ values in the human range (Figure 2.4). A possible explanation is that they could perhaps be young nursing animals (Mays et al. 2002).

The C_3 and C_4 plants have distinct values for the carbon isotope. The average values are −26.7‰ and −12.6‰ for C_3 and C_4, respectively (Vogel 1980). Papathanasiou and Richards in their recent article (2015) collected human and animal isotopic data from various Greek sites from the Mesolithic to the Byzantine period in order to examine the diet throughout the periods. They noticed that almost all sites clus- ter below −19‰, indicating dietary protein from C_3 terrestrial re- sources. Some human individuals exhibited $\delta^{13}C$ values higher than this cut-off point, while the $\delta^{15}N$ values were low. It has been suggested by the authors that this is an indication of C_4 additions. Based on that study for Greek assemblages as well as the study by Pearson et al. (2007), where they suggested a cut-off point to be −18‰, in this paper, individuals with $\delta^{13}C$ values from −19‰ to −18‰ will be considered to have minor additions of C_4 products while individuals with more positive than −18‰ $\delta^{13}C$ values will be considered as regular users of C_4 resources. However, it has to be stressed that these individuals did not consume exclusively C_4 protein, but they used C_4 products to supplement their diet, which mainly consisted of C_3 plant and animal protein.

Six adults from Voulokaliva exhibit more positive than −19‰ $\delta^{13}C$ values. For four individuals there was less C_4 contribution in their diet, but for another two C_4 consumption, as indicated by the range: −17.5‰ to −17.0‰, was considerable. Seven subadults also show C_4 resources, five ranging from −18.7‰ to −18.1‰ and two more from −18.0‰ to −17.2‰ (Figure 2.5a). It is important to mention that these two individuals were younger than 2 years, still nursing, and therefore refiecting their mothers' diet.

Breastfeeding plays a significant role in infants' diet, and is detected by the higher trophic level that the consumer occupies compared to the food (breast-milk: mother's tissue) (Mays et al. 2002). Breastfeeding is confirmed in Halos by the one higher trophic level that infants lie on above the adult females of the same group (Figure 2.5a) which is statistically significant (t-test, t=3.592, with a p-value b 0.00147).

The age at which supplementary food was introduced is, however, difficult to establish. All individuals between new-born and 2-years-old (11 out of 22 subadults) exhibit $\delta^{15}N$ values between 8.5‰ and 11.7‰ (Figure 2.5b). The group of 3-year-old children (n=3) have varying $\delta^{15}N$ values. Two of them have low $\delta^{15}N$ values, 7‰-8‰ (HaVo/e-c37/ind2, HaVo/e-c70), which indicates that they had been weaned, while the $\delta^{15}N$ value of the third child is comparable to that of infants who still depend entirely on breastfeeding (HK/B7-c10: 10‰). It can be suggested that weaning was taking place around a child's third year, but this was not followed in all cases.

The 4-year-old children (n=4) show relatively high $\delta^{15}N$ values, higher than the 3-year-old ones, while, according to the argument presented above, they should have already been weaned. This suggests

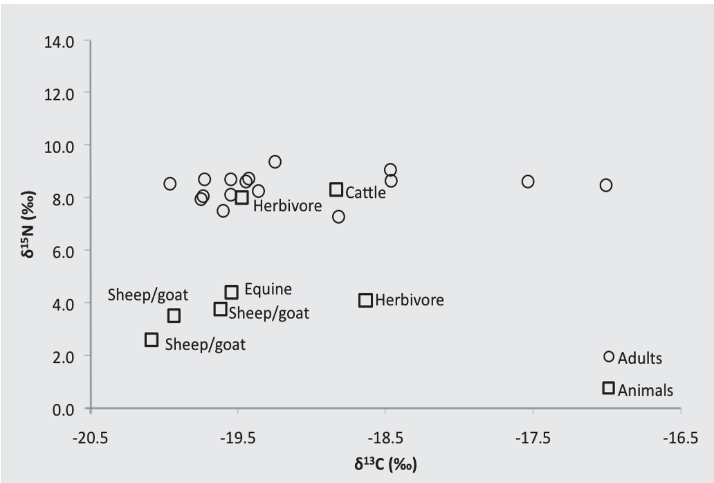

Figure 2.4: $\delta^{13}C$ and $\delta^{15}N$ values of bone collagen from the Halos cemeteries for adult humans and animals (single column).

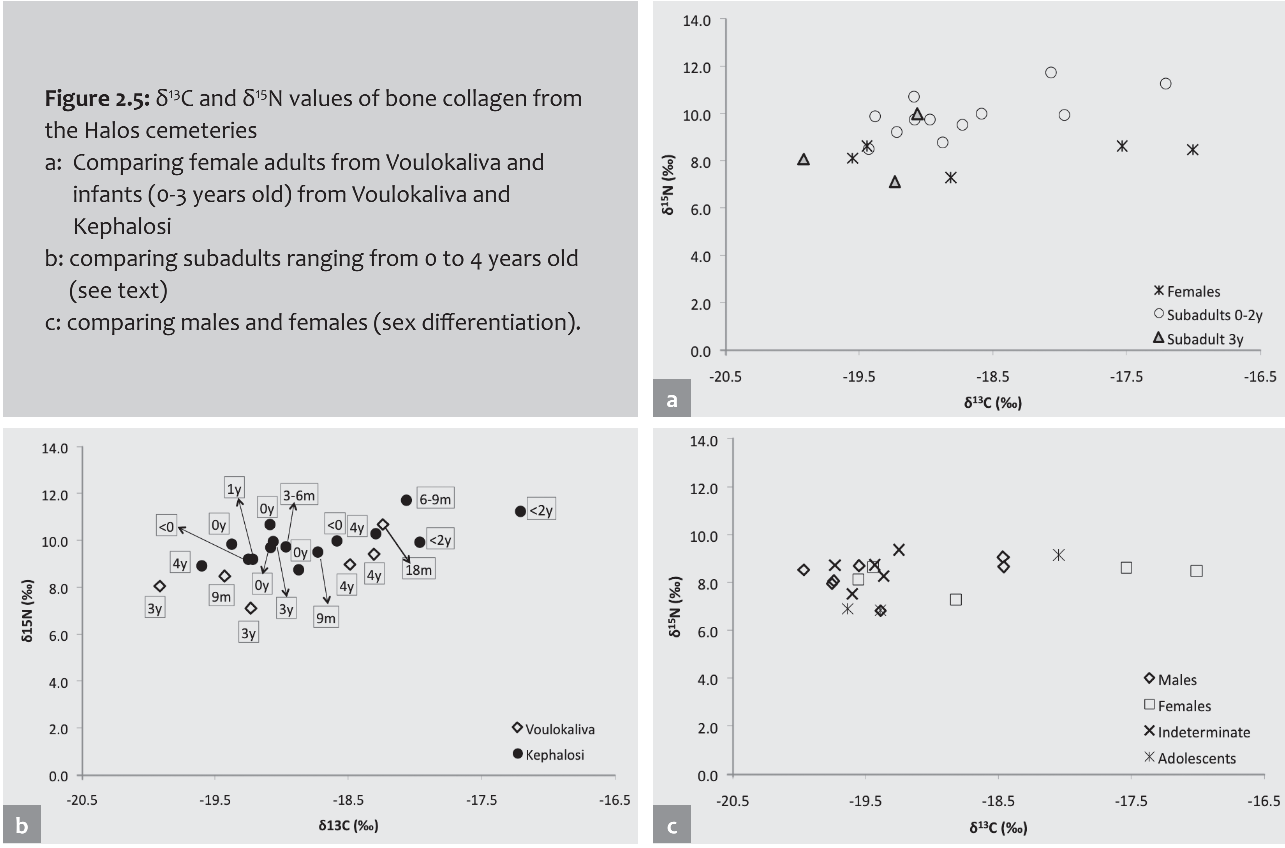

Figure 2.5: $\delta^{13}C$ and $\delta^{15}N$ values of bone collagen from the Halos cemeteries
a: Comparing female adults from Voulokaliva and infants (0-3 years old) from Voulokaliva and Kephalosi
b: comparing subadults ranging from 0 to 4 years old (see text)
c: comparing males and females (sex differentiation).

either that a few 4-year-old children were still being breastfed, or that they consumed animal protein, for example animal milk without addition of plant protein. However, our sample is not large enough to explore this question further.

2.4. Discussion

This article focuses on dietary variation among the population of Protogeometric Halos and its correlation with the social differentiation. The diet consisted mainly of C_3 terrestrial resources including plant and animal protein, as the carbon and nitrogen isotopic values indicated. However, our study also reveals a considerable contribution of C_4 resources (Figure 2.4).

Isotopic studies on assemblages from sites in the Greek mainland from the prehistoric (Iezzi 2009; Papathanasiou 2003; Papathanasiou et al. 2009) to the Ottoman period (Garvie-Lok 2001; Bourbou and Richards 2007; Bourbou and Garvie-Lok 2015) have shown that the diet largely relied on C_3 terrestrial plant and/or animal protein. However, Greek diet exhibits subtle variation and changes throughout Antiquity, with higher or lower animal protein and C_4 intake.

More specifically, C_4 has been detected isotopically as human food very rarely in the Neolithic period (6800–3000 BCE) (Papathanasiou 2003) and the Bronze Age (Ingvarsson-Sundström et al. 2009; Schepartz et al. 2009; Schepartz et al. 2008). Studies interpreted the C_4 signal as coincidental – that is they attributed it to the consumption of wild grasses by animals (Petroutsa and Manolis 2010; Petroutsa 2007), while more regular use of C_4 resources begun by the end of Late Bronze and mostly during the Iron Age (Triantaphyllou 2001).

The limitations of the technique should be kept in mind, since isotopes cannot distinguish between different plant species. It is therefore important to integrate isotopic with archaeobotanical data, which help us distinguish different plant species. Recent archaeobotanical studies have indicated millet as the source of edible C_4 plants in Greece (Valamoti 2013; Valamoti 2004) and have strengthened the isotopic evidence of widespread exploration of millet during the end of Bronze Age and the beginning of Early Iron Age (Jones et al. 1986; Valamoti 2013; Valamoti 2010).

Only few isotopic studies have been undertaken on EIA assemblages. These include Agios Dimitrios in central Greece (Panagiotopoulou 2010; Papathanasiou et al. 2013) and the sites Treis Elies (Pantermali 1988; Poulaki-Pantermali 1989; Triantaphyllou 2001), Karitsa, Kladeri (Triantaphyllou 2015; Vokotopoulou 1985), and Makrigialos (Bessios 1996; Triantaphyllou 2001) in northern Greece. No materials from EIA sites in southern Greece have been analysed so far.

These different studies showed that, C_4 was more systematically explored during the EIA, although the evidence becomes uncertain as we go further to the south. The site of Agios Dimitrios has mainly C_3 human signal while the signal from the northern EIA sites definitely indicates the use of millet. In the case of Halos C_4 resources appear to have been consumed systematically though only by a few individuals.

Most animal samples at Halos cluster at the plot area of C_3 terrestrial diet (Figure 2.4) but only one cattle and one herbivore have traces of C_4 diet. C_4 consumption by the humans cannot be explained as incidental because a) a strong signal should be a result of regular consumption, which is not supported by the animal values, and b) this should hold for the entire population if we assume that the animals grazed in the same general area. Isotope analyses may shed light on social differentiation, for instance, gender relations. Isotope analyses of the human remains from Pylos, a Mycenaean palatial town, pointed to status and gender differences as males clustered higher in $\delta^{15}N$ than females which indicates a higher animal protein intake (Schepartz et al. 2008).

The isotope analyses of the Halos material indicated some differences between the sexes (Figure 2.5c). Females exhibit slightly lower $\delta^{15}N$ values than males. However, no rigid differentiation can be observed because, a) not all males had high animal protein diet, and b) not all individuals with higher $\delta^{15}N$ are males, or rather some are indeterminate individuals. The difference between males and females is not statistically significant at the 95% level (*t*-test *t*-test: 0.076, with a p-value b 0.47062). We also observe variation at the $\delta^{13}C$ values (*t*-test: 1.691, with a p-value b 0.06088), which is also not statistically significant at the same level of confidence. However, the two most positive $\delta^{13}C$ values, suggesting additional C_4 consumption belong to females. This may be attributed to personal preference, or to a different geographical origin. A similar argument has been made about the use of millet; it was introduced by women who came from more distant communities (Valamoti, 2013). However, the contextual analysis did not detect differences in mortuary practices between these females and the rest of the population. We can therefore conclude that a subtle gender variation can be observed, but no pronounced differentiation.

Studies have shown that diet is associated with the social divisions in past societies. For instance, the isotope ratios of the elite population buried in the Grave Circles (ca. 17th-16th c. BC) at Mycenae, Argolid, consumed more marine resources than the non-elite individuals from the Mycenaean chamber tombs (ca. 1600–1200 BCE) (Richards and Hedges 2008).

Comparisons of subadults' $\delta^{15}N$ values of same age groups reveal dif- ferences between the two cemeteries in Halos (Figure 2.5b). The subadults with the lower values (4-9 y: 8.1±0.6 [n=3], 3 y: 7.6±0.7 [n=2], 0–2 y: 8.5 [n=1]) are buried at Voulokaliva (Table 2.4) while the values of the ones buried in Kephalosi are approximately 2‰ higher (Table 2.5) (4-9 y: 9.1±1 [n=6], 3 y: 10±1 [n=1], 0-2 y: 10.1±1 [n=9]). The only adult at Kephalosi exhibits also 2‰ higher $\delta^{15}N$ than the adults buried in Voulokaliva (Tables 2.4 & 2.5). The sample size of Voulokaliva is very small to reasonably support the use of statistical methods between the two sites.

The higher $\delta^{15}N$ values, in conjunction with the $\delta^{13}C$ values, in Kephalosi could be attributed to a higher animal protein intake, by the children or the mothers of the nursing subadults. The $\delta^{15}N$ of the females from Voulokaliva do not indicate high animal protein consumption; the difference in mean $\delta^{15}N$ values between females of Voulokaliva (n=5) and nursing subadults of Kephalosi (n=10) is approximately 2‰ while the difference between the highest $\delta^{15}N$ values of a nurshing child from Kephalosi and a female from Voulokaliva reaches 3.2‰. Furthermore, the differences in mean values between same subadult age groups indicate that the individuals from Kephalosi (elevated $\delta^{15}N$) possibly consumed more animal protein than the individuals from Voulokaliva.

This difference between the two cemeteries is reinforced by the differential use of millet between the two sites. The $\delta^{13}C$ values of the nursing subadults from Kephalosi ($\delta^{13}C$: −18.7±0.7, n=5) are depleted compared to females from Voulokaliva ($\delta^{13}C$: −17.8±0.9, n=3); this should be reversed, due to $\delta^{13}C$ enrichment of consumer against the dietary source (Fuller et al. 2006).

A possible explanation for the observed differentiation in $\delta^{15}N$ and $\delta^{13}C$ between individuals from the two cemeteries is that some adults of the population (mothers/families of the infants from Kephalosi) were buried either at another cemetery or at the unexcavated part of the cemetery of Voulokaliva. However, status should not be excluded as a possible reason for differentiation between the two cemeteries of Halos, although the contextual analysis did not indicate status differences in the mortuary record.

The contextual analysis of the cemeteries of Halos did not reveal differences in bone isotopic values between the people buried in different tomb types. All types are within the C_3 range with indication for some C_4 infiuence (Figure 2.6a) including the circular construction, which required more labour than the simple cists and pits.

In the contextual analysis we observed status differences on the basis of the offerings. Here, we would like to examine whether diet correlates with the variation observed in offerings. We propose to divide the graves into wealthy, poor and empty ones (Figure 2.6b). A grave with one offering per individual is considered here to be poor whereas one with more offerings per individual is considered rich. All groups show a range in $\delta^{13}C$ values from exclusive C_3 diet to an apparent mixture of C_3 – C_4 products (Figure 2.6b). We therefore observe considerable variation in $\delta^{13}C$ but no clear distinctions. Individuals from empty graves show a wider range of plant protein in their diet, with values lying in the C_4 area (n=3), than the individuals from the other two groups.

Table 2.4. Minimum, maximum and mean values of $\delta^{13}C$ and $\delta^{15}N$ for age groups of the Kephalosi cemetery.

Kephalosi	n	Min $\delta^{13}C$ (‰)	Max $\delta^{13}C$ (‰)	Mean $\delta^{13}C$ (‰)	SD $\delta^{13}C$	Min $\delta^{15}N$ (‰)	Max $\delta^{15}N$ (‰)	Mean $\delta^{15}N$ (‰)	SD $\delta^{15}N$
Adults	1		–	−19.1	–	–	–	9.7	–
Subadults 4y-9y	6	−19.6	−18.3	−19.2	0.5	7.8	10.3	9.1	1.0
Subadulst 3y	1	–	–	−19.1	–	–	–	10.0	–
Subadults 0-2y	9	−19.4	−17.2	−18.6	0.7	8.8	11.7	10.1	1.0
Subadults ≥ 0y	3	−19.3	−18.6	−19.0	0.4	9.2	10.0	9.6	0.4
Animal	1	–	–	−18.8	–	–	–	8.3	–

Table 2.5. Minimum, maximum and mean values of $\delta^{13}C$ and $\delta^{15}N$ for age groups of the Voulokaliva cemetery.

Voulokaliva	n	Min $\delta^{13}C$ (‰)	Max $\delta^{13}C$ (‰)	Mean $\delta^{13}C$ (‰)	SD $\delta^{13}C$	Min $\delta^{15}N$ (‰)	Max $\delta^{15}N$ (‰)	Mean $\delta^{15}N$ (‰)	SD $\delta^{15}N$
Adults	17	−20.0	−17.0	−19.1	0.9	6.8	9.4	8.3	0.6
Males	7	−20.0	−18.5	−19.3	0.6	6.8	9.1	8.3	0.7
Females	5	−19.6	−17.0	−18.5	1.1	7.3	8.6	8.2	0.6
Indeterminate	5	−19.7	−19.3	−19.5	0.2	7.5	9.4	8.5	0.7
11y-18y	3	−20.0	−18.0	−19.2	1.0	6.9	9.2	8.1	1.1
4y-9y	2	−18.5	−18.3	−18.4	0.1	9.0	9.4	9.2	0.3
3y	2	−19.9	−19.2	−19.6	0.5	7.1	8.1	7.6	0.7
0-2y	1	–	–	−19.4	–	–	–	8.5	–
Animals	6	−20.08	−18.63	−19.45	0.54	2.59	8.29	4.94	2.26

Archaeobotanical investigations indicated that C_4 might have been used as human food either sporadically or regularly during periods of food shortage (Valamoti 2013). In addition, isotopic studies, so far, have not associated millet consumption with individuals of higher status (Papathanasiou 2015). It seems that C_4 consumption in Halos was observed mainly among those buried in poor and empty graves, while richer individuals were mainly relying on animal C_3 protein. On the other hand, two individuals from wealthier graves also presented C_4 traces. This suggests once more that no rigid divisions can be observed, but also that there is no clear evidence, which would allow to consider C_4 to be the 'food for the poor'.

We also examined diet in relation to the value of the offerings. Indeed individuals buried with weapons and gold ornaments produced higher nitrogen values indicating that a diet relying on animal protein might have been associated with higher status. On the other hand, however, also individuals buried in empty graves are found in the group showing higher nitrogen values.

To conclude: Our analyses, based on the integration of contextual analysis of mortuary data with stable isotope analysis of bone collagen, indicate a possible correlation between social differentiation patterns and diet.

2.5. Conclusions

The main goal of this paper was to reconstruct the social differentiation during the EIA in Thessaly, Greece by integrating the contextual analysis of mortuary practices with dietary reconstruction by stable isotope ($\delta^{13}C$ and $\delta^{15}N$) analysis. We designed the sampling strategy for the isotope analysis based on the results and questions generated by the contextual analysis of the mortuary data, and we compared the two sets of data in order to get a more holistic picture of differentiation between age, sex and status groups.

The contextual analysis of the two Early Iron Age cemeteries of Halos indicated a society organized mainly around age and gender divisions, while social status may have just been emerging in this period. We observed significant variation in the choice of burial locations and grave types, in the types and value of offerings as well as in the treatment of the deceased. However, we seem to be dealing with subtle variation rather than rigid divisions between social groups. The questions that emerged mainly concern the role of diet in the formation of these divisions and its correlation to the social aspect.

Gender differentiation is perhaps indicated by the strong signal of C_4 consumption by a few females. A few individuals with weapons and wealthier offerings exhibited higher animal protein intake, while the difference in $\delta^{13}C$ and $\delta^{15}N$ between the individuals from the two cemeteries indicates that C_4 and animal protein were not accessible or preferred by the entire population. We see the first steps of the development of social divisions.

The integration of the two methods has helped us to understand dietary variations among the inhabitants of EIA Halos, and enabled us to reach important conclusions on a

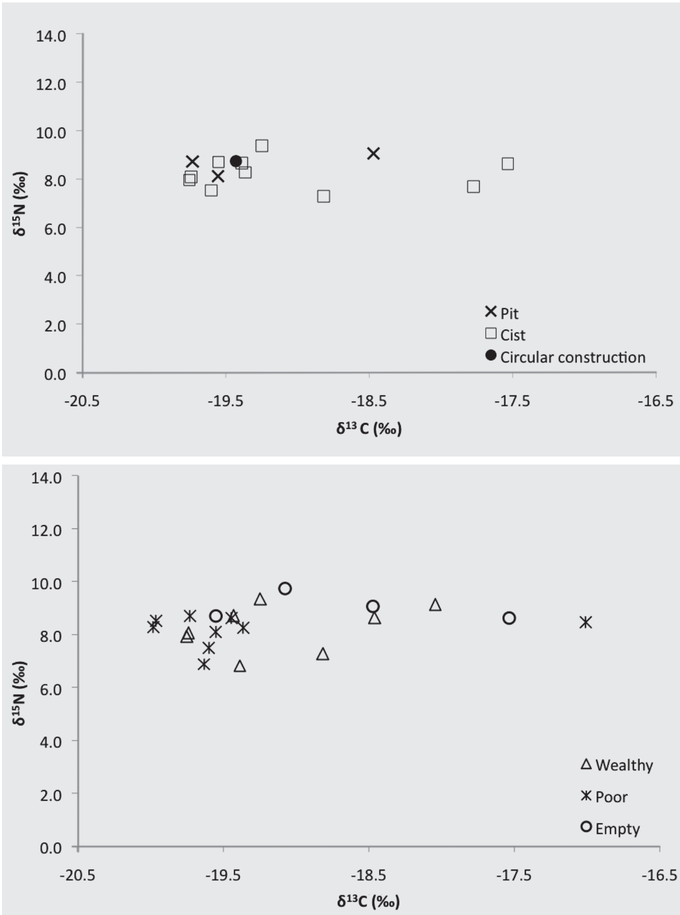

Figure 2.6. $\delta^{13}C$ and $\delta^{15}N$ values of bone collagen from the Halos cemeteries. a: grave types b: wealth status.

hitherto little investigated crucial period of Greek prehistory. However, the integrated approach adopted in this study has a wide relevance beyond Greek archaeology, as it allows us to control archaeological and isotopic data against each other, and to provide more nuanced interpretations of both.

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